US009499446B2

(12) **United States Patent**
Subramanyam

(10) **Patent No.: US 9,499,446 B2**
(45) **Date of Patent: Nov. 22, 2016**

(54) **ZINC-ESSENTIAL FOR FLORA AND FAUNA**

(71) Applicant: **Sundaresan Subramanyam**, Chennai (IN)

(72) Inventor: **Sundaresan Subramanyam**, Chennai (IN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/426,886**

(22) PCT Filed: **Aug. 14, 2013**

(86) PCT No.: **PCT/IN2013/000499**

§ 371 (c)(1),
(2) Date: **Mar. 9, 2015**

(87) PCT Pub. No.: **WO2014/041556**

PCT Pub. Date: **Mar. 20, 2014**

(65) **Prior Publication Data**

US 2015/0239787 A1 Aug. 27, 2015

(30) **Foreign Application Priority Data**

Sep. 12, 2012 (IN) 3789/CHE/2012

(51) **Int. Cl.**
C05B 17/00 (2006.01)
C05D 9/02 (2006.01)

(52) **U.S. Cl.**
CPC ***C05B 17/00*** (2013.01); ***C05D 9/02*** (2013.01)

(58) **Field of Classification Search**
CPC C05B 17/00; C05D 9/02; C05D 9/00; C05D 3/00; C05D 1/00; A01N 43/90; A01N 25/32; C05G 3/007; C05G 3/0005; C05F 11/02; C05C 3/00
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,620,708	A		11/1971	Ott	
5,021,077	A	*	6/1991	Moore	A23K 1/106 426/285
6,063,289	A	*	5/2000	Failon	C02F 5/14 210/699

OTHER PUBLICATIONS

HEDP Trade Info [online] Jing Xin (China), Mar. 11, 2012, Download: http://jijing-chem.en.made-in-china.com/product/veMmtqZoMwhP/China-HEDP-1-HYDROXY-Ethylidene-1-1-Disphosphonic-Acid.html [Downloaded: Mar. 2, 2015].
HEDP: 1-Hydroxy Ethylidene-1, 1-Diphosphonic Acid. Trade Info [online] SHR, Jining City Shandong Province China, Mar. 3, 2012. Download: http://www.made-in-china.com/showroom/pbte-chemical/product-detailgbimMCpVZSYe/China-HEDP-1-Hydroxy-Ethylidene-1-1-Diphosphonic-Acid.html [Downloaded: Mar. 2, 2015].

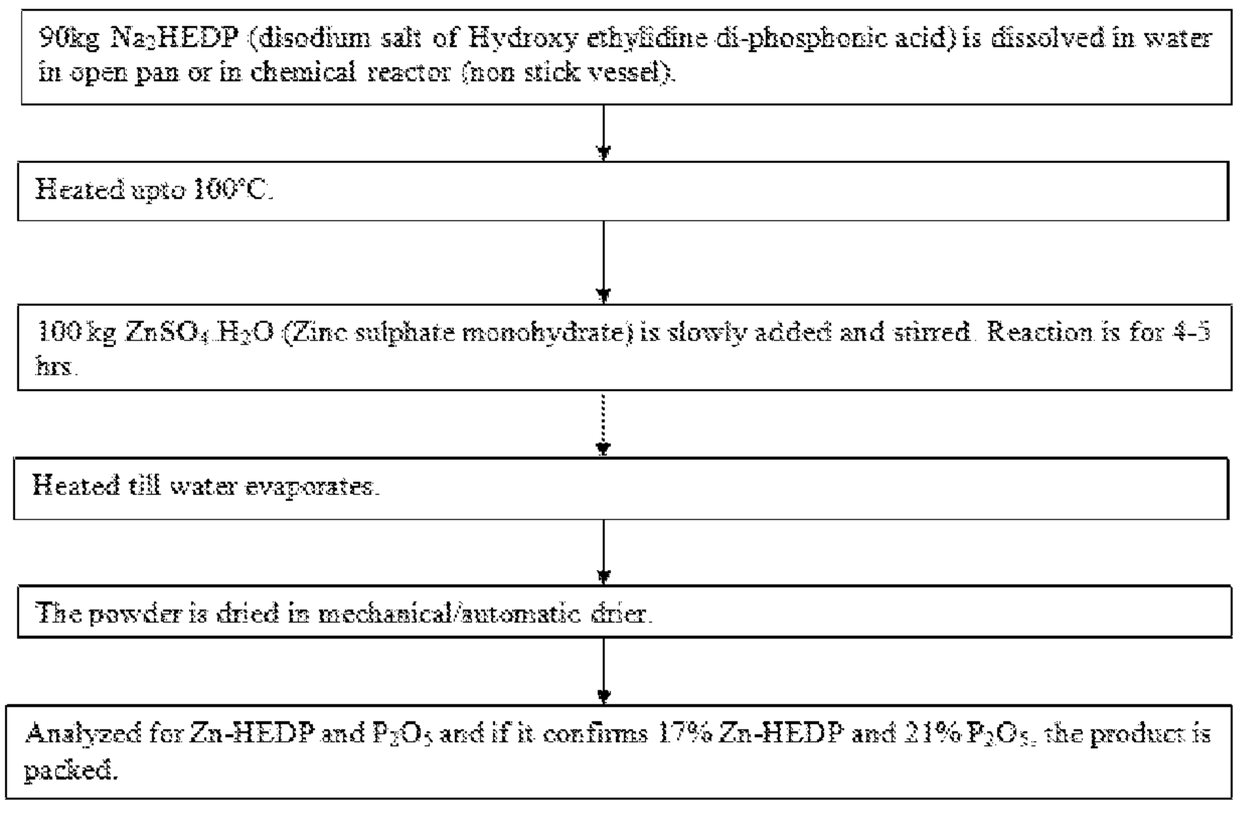
(Continued)

Primary Examiner — Jennifer A Smith
(74) *Attorney, Agent, or Firm* — Innovation Capital Law Group, LLP; Vic Lin

(57) **ABSTRACT**

The present invention relates to a chelated fertilizer composition for enriching Zinc and Phosphorus content in agriculture/horticulture crops and plants through foliar application. The chelated fertilizer composition can be prepared using compounds comprising (a) Na2 HEDP and ZnSO4.H2O (Zinc sulphate monohydrate) and (b) Na2 HEDP and ZnO (Zinc Oxide). The chelation of Zn by Na2 HEDP using ZnSO4.H2O developed 17% Zn-HEDP and 21% Phosphorus pentoxide (P2O5) and chelation of Zn by Na2 HEDP using ZnO developed 21% Zn-HEDP and 26% P2O5. The chelated fertilizer composition obtained is in powder form and is 100% water-soluble concentrate. The chelated fertilizer composition can be used to cure Zinc and Phosphorus deficiency in crops and plants, increase yield with more Zinc and Phosphorus content, thus reducing the risk of Zinc and Phosphorus deficiency in humans.

2 Claims, 2 Drawing Sheets



(56) **References Cited**

OTHER PUBLICATIONS

Zinc in Fertilizer: Options to consider [online information]; International Zinc Association; Download: www.zinc.org/crops; http://www.zinc.org/crops/resourceserve/zinc_in_fertilizers_options_to_consider [Downloaded: Mar. 6, 2015].

Zinc Fact Sheets: Zinc Fertilizer [online information]; International Zinc Association; Download: http://www.zinc.org/crops/resourceserve/zinc_fact_sheets_fertilizer_faqs [Down loaded: Mar. 6, 2015].

International Search Report (mailing date Nov. 22, 2013) for International PCT Application PCT/IN2013/000499, filed Aug. 14, 2013.

* cited by examiner

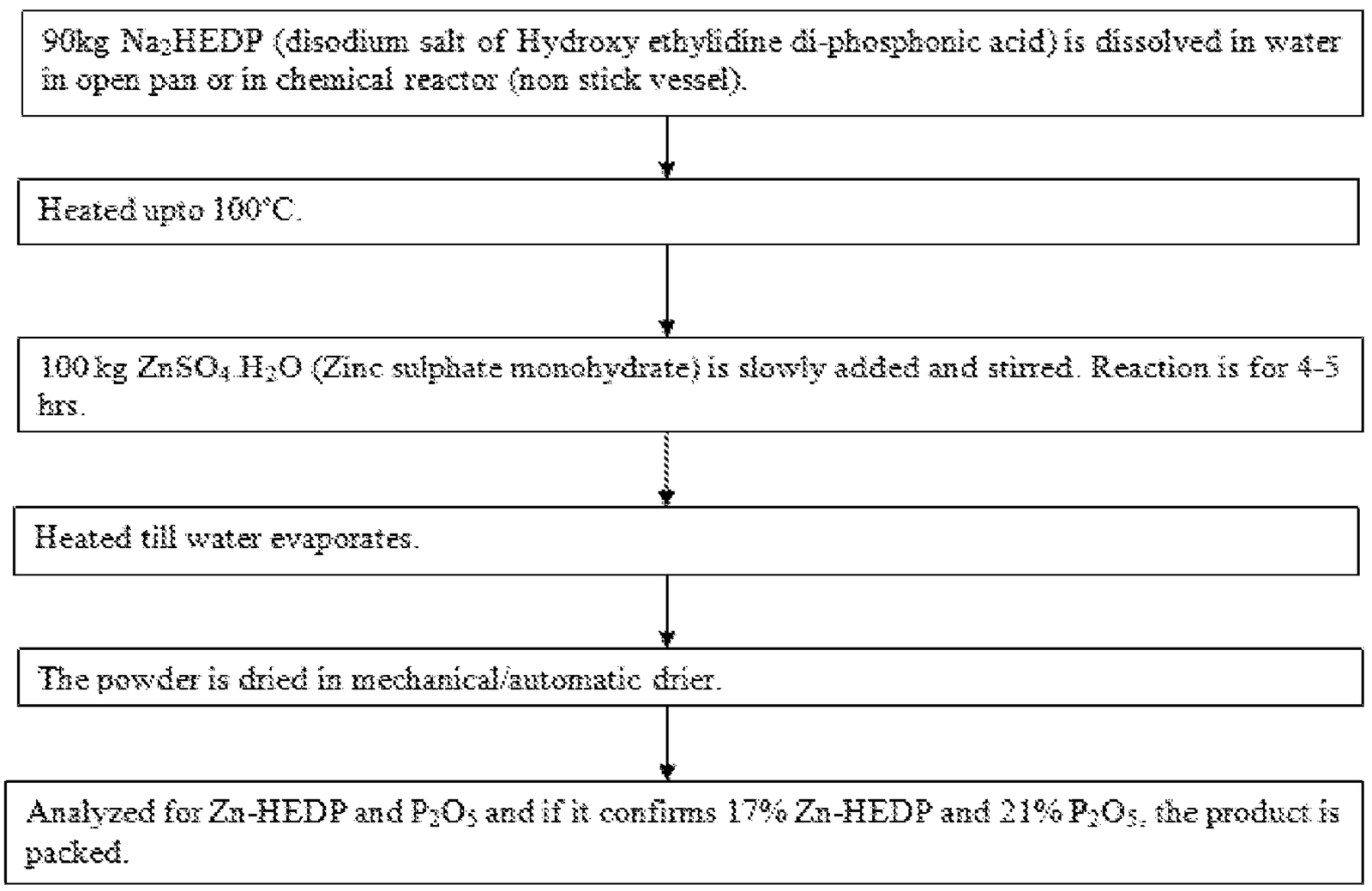

90kg Na_3HEDP (disodium salt of Hydroxy ethylidine di-phosphonic acid) is dissolved in water in open pan or in chemical reactor (non stick vessel).
Heated upto 100°C.
100 kg $ZnSO_4.H_2O$ (Zinc sulphate monohydrate) is slowly added and stirred. Reaction is for 4-5 hrs.
Heated till water evaporates.
The powder is dried in mechanical/automatic drier.
Analyzed for Zn-HEDP and P_2O_5 and if it confirms 17% Zn-HEDP and 21% P_2O_5, the product is packed.

FIG. 1

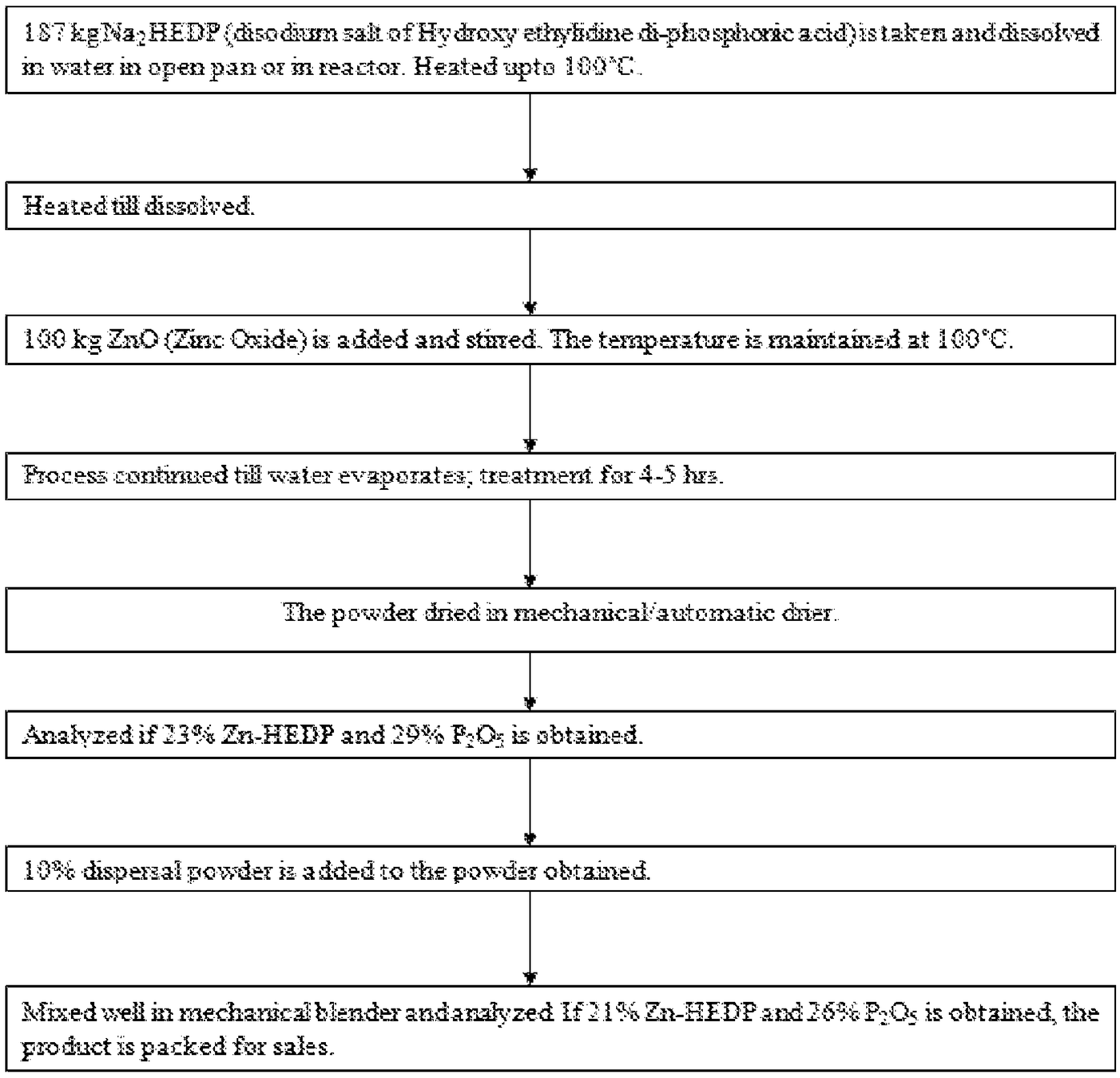

187 kg Na_2HEDP (disodium salt of Hydroxy ethylidine di-phosphoric acid) is taken and dissolved in water in open pan or in reactor. Heated upto 100°C.
Heated till dissolved.
100 kg ZnO (Zinc Oxide) is added and stirred. The temperature is maintained at 100°C.
Process continued till water evaporates; treatment for 4-5 hrs.
The powder dried in mechanical/automatic drier.
Analyzed if 23% Zn-HEDP and 29% P_2O_5 is obtained.
10% dispersal powder is added to the powder obtained.
Mixed well in mechanical blender and analyzed. If 21% Zn-HEDP and 26% P_2O_5 is obtained, the product is packed for sales.

FIG. 2

ZINC-ESSENTIAL FOR FLORA AND FAUNA

FIELD OF INVENTION

The present invention relates to a chelated fertilizer composition for agriculture/horticulture crops and plants. More specifically, the present invention relates to a chelated fertilizer composition for enriching Zinc and Phosphorus content in crops and plants through foliar application. Further, the present invention relates to a method of preparing the chelated fertilizer composition. The chelated fertilizer composition can be used to cure Zinc and Phosphorus deficiency in crops and plants, increase yield with more Zinc and Phosphorus content, thus reducing the risk of Zinc and Phosphorus deficiency in humans.

DESCRIPTION OF PRIOR ART

Zinc (Zn) is an essential micronutrient in crop/plant production and is used in many fertilizers. Some soil can supply the adequate amount of zinc to plants. In other cases where Zn exists in the soil in an unavailable form or the soil is Zn deficient, Zn fertilizers may be added to the soil to enrich soil fertility. Plants vary considerably in their requirement for Zn. Zn is an important component of various metallo enzymes such as carbonic anhydrase, alcohol dehydrogenase etc that are responsible for driving various metabolic reactions in plants. Zn is essential for the biosynthesis of the plant hormone indole acetic acid (IAA). Zn also plays a role in nucleic acid, protein synthesis and helps in the utilization of phosphorus and nitrogen in plants. Absence of Zn can affect growth and development in plants. Plants deficient in Zn show certain characteristic deficiency symptoms that may last through the entire growth season.

Though required in small quantities, Zn is also very essential for humans. Plant sources for Zn include cereals, nuts, legumes, soy products etc. In humans, Zn deficiency can cause appearance of white spots on nails, skin lesions, acne, diarrhea, wasting of body tissues etc. Zn plays an essential role in eyesight, taste, smell and memory. Deficiency in Zn can cause malfunctions of these organs and functions. Zn is an essential component in many enzymes and influences hormones. Zn also accelerates cell division and enhances the immune system. Congenital abnormalities causing Zn deficiency may lead to a disease called acrodermatitis enteropathica, a metabolic disorder affecting the uptake of Zn. Enriching plants used as food source with Zn helps to combat Zn deficiency in humans.

The importance of Zn has lead to the research in use of Zn in the sequestered form. Normally, cationic nutrients are fixed by anions. This leads to chelation i.e., sequestering. Once chelated, fixation and unwanted reaction will not affect. The chelation process will enable the nutrients to move freely inside the plants. Known in Prior Art is chelation of Zn using Ethylene diamine tetra acetic acid (EDTA) to give Zn EDTA. This sequestered form of Zn is used in agriculture as a micronutrient for plant growth. However, Zn EDTA gives only 12% Zn.

U.S. Pat. No. 5,047,078 describes a fertilizer composition comprising a phosphate fertilizer and a kale inhibiting compound that helps to increase plant growth and yield.

US20110098177 relates to a method of providing a metal to a plant to increase the yield.

US20030101785 describes micronutrient compositions having chelated metal ions. The chelating agents used are amino phosphonic acids.

US20080293570 describes a method of sequestering micronutrients to provide the micronutrients to a plant.

AU2006200467 relates to micronutrient chelate fertilizers and methods for preparing the same.

Accordingly, there exist a need for a fertilizer composition for improving the nutrient content in crops and plants, thereby overcoming the problems associated with nutrient deficiencies.

OBJECTS OF INVENTION

The primary object of the present invention is directed to provide a chelated fertilizer composition for agriculture/horticulture crops and plants.

It is another object of the present invention to provide a chelated fertilizer composition for enriching Zinc (Zn) and Phosphorus (P) content in crops and plants through foliar application.

It is another object of the present invention to provide a method of preparing the chelated fertilizer composition.

It is another object of the present invention, wherein the chelated fertilizer composition is used to cure Zn and P deficiency in crops and plants, increase yield with more Zn and P content, thus reducing the risk of Zn and P deficiency in humans.

It is another object of the present invention, wherein sequestration of Zn is done using a chelating agent—disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP).

It is another object of the present invention, wherein the chelated fertilizer composition can be prepared using compounds comprising Na_2 HEDP and $ZnSO_4.H_2O$ (Zinc sulphate monohydrate).

It is another object of the present invention, wherein the chelated fertilizer composition can be prepared using compounds comprising Na_2 HEDP and ZnO (Zinc Oxide).

It is another object of the present invention, wherein chelation of Zn by Na_2 HEDP using $ZnSO_4.H_2O$ developed 17% Zn-HEDP and 21% Phosphorus pentoxide (P_2O_5).

It is another object of the present invention, wherein chelation of Zn by Na_2 HEDP using ZnO developed 21% Zn-HEDP and 26% P_2O_5.

It is another object of the present invention, wherein the Zn-HEDP increases the yield upto 27% and the Zn content is increased upto 85% in Grains compared to control.

It is another object of the present invention, wherein the P_2O_5 increases the yield and Phosphorous concentration of crops and plants.

It is another object of the present invention, wherein the chelated fertilizer composition obtained is in powder form and is 100% water-soluble concentrate.

SUMMARY OF INVENTION

Thus according to the basic aspect of the present invention, there is provided a chelated fertilizer composition for use as a foliar fertilizer for enrichment of Zinc (Zn) and Phosphorus (P) in crops and plants comprising:

Zinc (Zn) chelate; and

Phosphorus pentoxide (P_2O_5),

wherein the Zinc chelate is Zn-Hydroxy Ethylidene Di Phosphonic Acid (HEDP), and

wherein the chelated fertilizer composition is in powder form and is 100% water soluble concentrate.

A further aspect of the present invention is directed to provide a chelated fertilizer composition, wherein the fertilizer composition is prepared using compounds comprising:

Chelating agent; and

Zinc sulphate monohydrate ($ZnSO_4.H_2O$),

wherein the chelating agent is disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP).

A further aspect of the present invention is directed to provide a chelated fertilizer composition, wherein the fertilizer composition is prepared using compounds comprising:

Chelating agent; and

ZnO (Zinc Oxide),

wherein the chelating agent is disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP).

It is another aspect of the present invention, wherein the Zinc chelate (Zn-Hydroxy Ethylidene Di Phosphonic Acid) is obtained by sequestration of Zinc (Zn) using the chelating agent.

It is another aspect of the present invention, wherein the chelated fertilizer composition in powder form contains 17% Zn-HEDP and 21% P_2O_5 by weight of the composition.

It is another aspect of the present invention, wherein the chelated fertilizer composition in powder form contains 21% Zn-HEDP and 26% P_2O_5 by weight of the composition.

It is another aspect of the present invention, wherein pH of the chelated fertilizer composition is between 3.5 and 4.5.

A further aspect of the present invention is directed to provide a process for preparing the chelated fertilizer composition using compounds comprising disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP) and $ZnSO_4.H_2O$ (Zinc sulphate monohydrate), comprising the steps of:

Dissolving Na_2 HEDP in water;

Heating the dissolved mixture up to 100° C. in a non-stick temperature controlled vessel/reactor;

Adding $ZnSO_4.H_2O$ slowly and stirring to obtain mixture containing Zn-HEDP and P_2O_5;

Maintaining the temperature at 100° C. and stirring the mixture until liquid portion evaporates; and

Drying the composition thus obtained using drier to secure moisture free powder composition containing 17% Zn-HEDP and 21% P_2O_5,

wherein the chelated fertilizer composition is in powder form and is 100% water soluble concentrate.

A further aspect of the present invention is directed to provide a process for preparing the chelated fertilizer composition using compounds comprising disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP) and ZnO (Zinc Oxide), comprising the steps of:

Dissolving Na_2 HEDP in water;

Heating the dissolved mixture up to 100° C. in a non-stick temperature controlled vessel/reactor;

Adding ZnO slowly and stirring to obtain mixture containing Zn-HEDP and P_2O_5;

Maintaining the temperature at 100° C. and stirring the mixture until liquid portion evaporates;

Drying the composition thus obtained using drier to secure moisture free powder composition containing 23% Zn-HEDP and 29% P_2O_5;

Adding 10% dispersal powder; and

Mixing in blender to obtain 21% Zn-HEDP and 26% P_2O_5,

wherein the chelated fertilizer composition is in powder form and is 100% water soluble concentrate.

BRIEF DESCRIPTION OF THE FLOWCHARTS

FIG. **1** is a flowchart illustrating the process for preparing the chelated fertilizer composition using Na_2 HEDP and $ZnSO_4.H_2O$.

FIG. **1** is a flowchart illustrating the process for preparing the chelated fertilizer composition using Na_2 HEDP and ZnO.

DETAILED DESCRIPTION OF THE INVENTION WITH REFERENCE TO THE ACCOMPANYING DRAWINGS

The present invention relates to a chelated fertilizer composition for agriculture/horticulture crops and plants, and a method of preparing the chelated fertilizer composition. The present invention provides a chelated fertilizer composition for enriching Zinc (Zn) and Phosphorus (P) content in crops and plants through foliar application. Zn-HEDP increases the yield up to 27% and the Zn content is increased up to 85% in grains compared to control.

The chelated fertilizer composition is used to cure Zn and P deficiency in crops and plants, increase yield with more Zn and P content, thus reducing the risk of Zn and P deficiency in humans. The sequestration of Zn is done using a chelating agent—disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP). The chelated fertilizer composition can be prepared using either compounds comprising Na_2 HEDP and $ZnSO_4.H_2O$ (Zinc sulphate monohydrate), or compounds comprising Na_2 HEDP and ZnO (Zinc Oxide). The Zn chelate increases the yield and Zn concentration and P_2O_5 increases the yield and Phosphorous concentration of crops and plants.

In one embodiment of the present invention, the chelated fertilizer composition is obtained using. Na_2 HEDP and $ZnSO_4.H_2O$, heated at 100° C. to give 17% Zn-HEDP and 21% P_2O_5 in powder form as shown below. The chelated fertilizer composition thus obtained is completely soluble.

$$ZnSO_4 \cdot H_2O + Na_2\,HEDP\ solution \xrightarrow{100^\circ C.} \text{Dissolved, dried and secure composition}$$

The process of preparing the chelated fertilizer composition as illustrated in the flow chart of FIG. **1** using Na_2 HEDP and $ZnSO_4.H_2O$ comprises dissolving 90 Kg Na_2 HEDP in water. 90 Kg Na_2 HEDP contains 40.89 gram P_2O_5. The dissolved mixture is heated up to 100° C. in a non-stick temperature controlled vessel/reactor or open pan. Further 100 Kg $ZnSO_4.H_2O$ containing 33 gram Zn is slowly added and the mixture is stirred. During this process, the temperature is maintained at 100° C. and the mixture stirred for 4-5 hours until the liquid portion evaporates. The composition thus obtained is dried using mechanical/automatic drier to secure moisture free powder containing 17% Zn HEDP and 21% P_2O_5. Chelation makes the composition completely soluble. The composition is analyzed and packed for market. The pH of the chelated fertilizer composition is between 3.5 and 4.5.

Lab Grade $ZnSO_4.H_2O$—2.27 gm Zinc—5 gm 100% HEDP,

whereas in prior art:

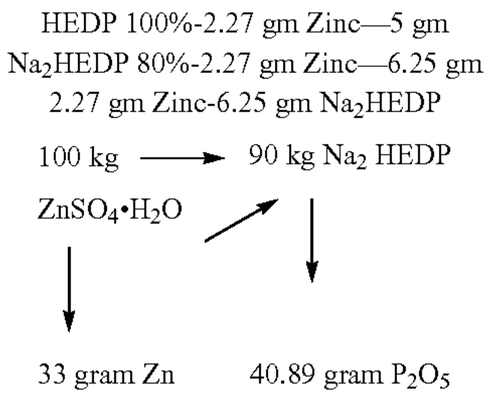
Lab Grade $ZnSO_4.H_2O$—2.27 gm Zinc—11.13 gm EDTA

The method of preparing the chelated fertilizer composition using Na_e HEDP and $ZnSO_4.H_2O$ is summarized as follows:

HEDP 100%-2.27 gm Zinc—5 gm

Na_2HEDP 80%-2.27 gm Zinc—6.25 gm

2.27 gm Zinc-6.25 gm Na_2HEDP



-continued

$$\text{Zn-HEDP-}\frac{33}{190}\times 100 \longrightarrow 17\%\ \text{Zn-HEDP}$$

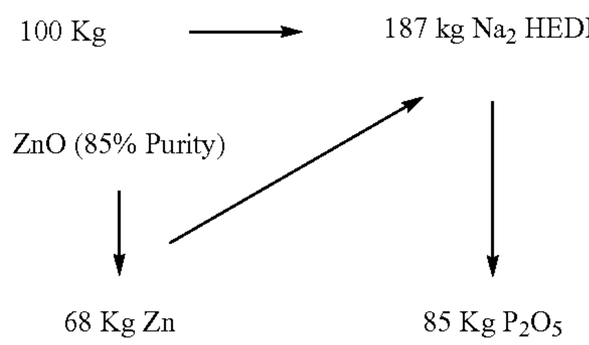
$$P_2O_5\text{-}\frac{40.89}{190}\times 100 \longrightarrow 21\%\ P_2O_5$$

In another embodiment of the present invention, the chelated fertilizer composition is obtained using Na_2 HEDP and ZnO, heated at 100° C. to give 21% Zn-HEDP and 26% P_2O_5 in powder form as shown below. The chelated fertilizer composition thus obtained is completely soluble.

$$ZnO + Na_2\ HEDP\ solution \xrightarrow{100^\circ\ C.} \text{Dissolved, dried and secure composition}$$

The process of preparing the chelated fertilizer composition as illustrated in the flow chart of FIG. **2** using Na_2 HEDP and ZnO comprises dissolving 187 Kg Na_2 HEDP in water. 187 Kg Na_2 HEDP contains 85 Kg P_2O_5. The dissolved mixture is heated up to 100° C. in a non-stick temperature controlled vessel/reactor or open pan. Further, 100 Kg ZnO containing 68 Kg Zn is slowly added and the mixture is stirred. During this process, the temperature is maintained at 100° C. and the mixture stirred for 4-5 hours until the liquid portion evaporates. The composition thus obtained is dried using mechanical/automatic drier to secure moisture free powder containing 23% Zn-HEDP and 29% P_2O_5. 10% dispersal powder is added and mixed well in mechanical blender to obtain 21% Zn-HEDP and 26% P_2O_5. Chelation makes the composition completely soluble. The composition is analyzed and packed for market. The pH of the chelated fertilizer composition is between 3.5 and 4.5.

The method of preparing the chelated fertilizer composition using Na_2 HEDP and ZnO is summarized as follows:
2.27 gm Zinc needs 5 gm 100% HEDP
2.27 gm Zinc needs 6.25 gm Na_2 HEDP



$$\text{Zn-HEDP} - \frac{68}{287}\times 100 \rightarrow 23\%\ \text{Zn-HEDP}$$

$$P_2O_5 - \frac{85}{287}\times 100 \rightarrow 29\%\ P_2O_5$$

The chelated fertilizer composition Obtained by adding 10% dispersal is

$$\text{Zn-}HEDP - \frac{68}{316}\times 100 \rightarrow 21\%\ \text{Zn-}HEDP$$

$$P_2O_5 - \frac{85}{316}\times 100 \rightarrow 26\%\ P_2O_5$$

Various field experiments were conducted to study the effect of Zn-HEDP chelate on plants.

Experiment I

Field Experiments in wheat was carried out using the composition of the present invention for two consecutive years in Punjab Agriculture University (PAU) Research Farm and Framer's field (Jattpur) loamy soil. Wheat cultivar PBW 550 seeds were sown during the first week of November. Two Zn chelates at different concentrations at two stages of wheat plant growth were applied through foliar application. In another treatment, Zn was added to the soil as basal dose at 62.5 kg ha^{-1} using $ZnSO_4.7H_2O$ salt. The first application of Zn chelate spray was done at maximum tillering stage and the second application was made at panicle initiation stage. The different treatments are shown in Table 1. Various parameters like plant height, tillers and 1000-grain weight were noted. Additionally during maturity in the month of April, the wheat grain and straw yield were noted.

TABLE 1

Different Zinc chelate treatments used for the above experiment

Treatments	Name of Chemical/Chelate	Concentration of Chemical/Chelate
T_1	$ZnSO_4 \cdot 7H_2O$ (soil application)	62.5 kg ha^{-1}
T_2	Zn HEDP (C) (foliar spray)	2 gram $liter^{-1}$
T_3	Zn HEDP (C) (foliar spray)	3 gram $liter^{-1}$
T_4	Zn HEDP (L) (foliar spray)	2 gram $liter^{-1}$
T_5	Zn HEDP (L) (foliar spray)	3 gram $liter^{-1}$
T_6	No Zn (Control)	Nil

The physio-chemical analyses of the soil before the start of the experiment was carried out at the two locations were the experiments were to be carried. The soil properties of the experimental fields before the start of the experiment are shown in Table 2.

TABLE 2

Soil properties of the experimental fields before the start of the experiment

	Soil Properties Texture	
	PAU research farm sandy loam	Farmer's field (Jattpur) loamy sand
pH (1:2:: soil:water)	7.5	7.8
Electric Conductivity (dS m^{-1})	0.16	0.12
Organic Carbon (%)	0.46	0.30
Available Nitogen (kg ha^{-1})	280	240
Available Phosphorus (kg ha^{-1})	18.0	15.4
Available Potassium (kg ha^{-1})	285	260
Available Zinc (mg kg^{-1})	0.86	0.52

The plant parameters in wheat under different Zn treatments at PAU research farm and farmer's field are shown in Table 3 and Table 4 respectively and grain and straw yields in wheat under different Zn treatments at PAU research farm and farmer's field are shown in Table 5 and Table 6 respectively.

TABLE 3

Plant parameters in wheat under different Zn treatments at PAU research farm

Treatment	Rabi 2009-2010			Rabi 2010-2011		
	Plant height (cm)	Tillers per square meter	1000 grains weight (g)	Plant height (cm)	Tillers per square meter	1000 grains weight (g)
T_1	76.7	293	38.4	97.69	377	38.7
T_2	76.1	291	36.8	95.23	372	36.9
T_3	77.4	294	38.4	96.20	381	39.2
T_4	79.6	287	37.6	95.90	373	38.1
T_5	78.0	295	38.7	96.81	383	39.8
T_6	74.2	275	34.4	93.65	357	35.5
Mean	76.9	289	37.4	95.91	373	38.0
CD (0.05)	4.2	9.5	2.9	NS	NS	2.51

TABLE 4

Plant parameters in wheat under different Zn treatments at farmer's field

Treatment	Rabi 2009-2010			Rabi 2010-2011		
	Plant height (cm)	Tillers per square meter	1000 grains weight (g)	Plant height (cm)	Tillers per square meter	1000 grains weight (g)
T_1	76.6	272	35.1	74.7	353	34.3
T_2	71.9	254	34.9	68.1	320	33.4
T_3	75.9	255	33.9	73.3	333	33.8
T_4	76.2	261	33.7	69.9	318	32.7
T_5	73.6	266	33.3	70.7	340	33.2
T_6	72.0	248	31.1	66.7	290	30.8
Mean	74.4	259	33.7	70.6	326	33.0
CD (0.05)	4.0	10.1	1.9	4.02	6.28	0.75

TABLE 5

Grain and Straw yields (q ha^{-1}) in wheat under different Zn treatments at PAU research farm

Treatments	Rabi 2009-2010				Rabi 2010-2011			
	Grain	% increase over control	Straw	% increase over control	Grain	% increase over control	Straw	% increase over control
T_1	52.5	10.8	65.0	3.7	54.4	13.3	65.7	5.5
T_2	51.0	7.6	65.4	4.3	50.5	5.2	66.9	7.4
T_3	51.2	8.0	67.6	7.8	51.5	7.3	69.6	11.7
T_4	48.8	3.0	64.6	3.0	52.2	8.8	73.9	18.6
T_5	52.0	9.7	66.7	6.4	53.4	11.3	74.1	18.9
T_6	47.4	0.0	62.7	0.0	48.0	0.0	62.3	0.0
Mean	50.5	6.5	65.3	4.2	51.7	7.6	68.8	10.4
CD (0.05)	3.6	—	4.4	—	2.90	—	NS	—

TABLE 6

Grain and Straw yields (q ha^{-1}) in wheat under different Zn treatments at farmer's field

Treatments	Rabi 2009-2010				Rabi 2010-2011			
	Grain	% increase over control	Straw	% increase over control	Grain	% increase over control	Straw	% increase over control
T_1	46.7	28.7	55.3	9.1	46.0	28.5	54.7	20.8
T_2	45.0	24.0	56.0	10.5	43.2	20.7	48.5	7.1
T_3	46.0	26.7	58.3	15.0	44.7	24.9	50.3	11.0
T_4	44.3	22.0	52.3	3.2	43.0	20.1	49.3	8.8
T_5	46.3	27.5	59.0	16.4	45.6	27.4	52.5	15.9
T_6	36.3	0.0	50.7	0.0	35.8	0.0	45.3	0.0
Mean	44.1	21.5	55.3	9.0	43.1	20.3	50.1	10.6
CD (0.05)	2.52	—	2.37	—	2.25	—	NS	—

Experiment II

Field Experiments in wheat was carried out using the composition of the present invention in the soils of the irrigated north-west plain zone of Rajasthan. The soils of north-west plain zone are deficient in zinc and poor growth or deficiency symptoms appear on the wheat crops. The different treatments used for Experiment II are shown in Table 7. Two foliar sprays were applied. First, during the vegetative growth stage on early appearance of the deficiency symptoms and the second foliar spray during the flag leaf initiation stage of the wheat crop.

TABLE 7

Different Zinc chelate treatments used for experiment II

TREATMENTS	NAME OF CHEMICAL/ CHELATE	CONCENTRATION OF CHEMICAL/CHELATE
T_1	No Zn (Control)	Nil
T_2	Zn HEDP (C) (foliar spray)	2 gram $liter^{-1}$ of water
T_3	Zn HEDP (C) (foliar spray)	3 gram $liter^{-1}$ of water
T_4	Zn HEDP (L) (foliar spray)	2 gram $liter^{-1}$ of water
T_5	Zn HEDP (L) (foliar spray)	3 gram $liter^{-1}$ of water
T_6	$ZnSO_4$	24 kg ha^{-1}

The soil of the irrigated north-west plain zone of Rajasthan has a pH, of 8.27 and electric conductivity was 0.20 dS^{-m}. The soil has an organic carbon content of 0.23%, which is low, medium in available P_2O_5 i.e. 25.0 kg ha^{-1} and high in available K_2O i.e. 250 kg ha^{-1}. The diethylene triamine pentaacetic acid (DTPA) extractable zinc concentration in the soil was low. The wheat grain and straw yield were increased with the foliar application of Zn chelate at lower concentration Zn-HEDP (C) –2 gram $liter^{-1}$ of water. Other ancillary characters such as tillering and ear length significantly increased over the control treatment as shown in Table 8. The foliar application significantly increased thousand grain weights over the control treatment.

TABLE 8

Effect of the Zn chelate on yield and ancillary parameters of wheat crops

	Yield (tonne ha^{-1})		No. of tillers m^{-1} row	1000 Grain weight	Ear length	Zn conc (mg
Treatments	Grain	Straw	length	(g)	(cm)	kg^{-1})
T_1	4.13	5.20	112	35.60	9.28	23.50
T_2	4.56	6.61	123	40.53	10.10	38.25
T_3	4.50	6.52	115	38.43	9.93	32.00
T_4	4.34	6.80	117	40.05	10.43	31.50
T_5	4.42	6.58	116	39.68	10.08	30.50
T_6	4.57	6.61	122	39.73	10.18	30.25
SEM	0.10	0.25	2.95	1.08	0.19	2.20
C.D. at 5%	0.31	0.74	8.88	3.25	0.58	6.60

Experiment III

Field experiments in transplanted rice were carried out using the composition of the present invention in Krishna-Godavari zone of Coastal Andhra Pradesh during rabi, 2008-2009. The climate conditions prevailing in this region are tropical, subtropical, humid to sub humid climate. The composition of the present invention (Zn-HEDP) was applied at two levels i.e. at 1 g and 2 g per liter to be sprayed at three stages 20, 40 and 60 days after transplanting rice crop. The prior art composition Zn-EDTA is also compared at similar doses of 1 g and 2 g in one liter water and also sprayed at 20, 40 and 60 days. Table 9 shows the effect of the above Zn compositions on rice grain and straw yields and Table 10 shows the effect of zinc compositions on yield components of rice.

TABLE 9

Effect of Zn compositions on rice grain and straw yields

S. No	Treatment	Plant ht. (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)	Total biomass (kg/ha)
T1	Zn HEDP@ 1 g/lt.	91.30	5717	4816.5	10558
T2	Zn HEDP @ 2 g/lt.	97.28	6005	5287.5	11210
T3	Zn EDTA @ 1 g/lt.	90.80	5630	4895.5	10405
T4	Zn EDTA @ 2 g/lt.	94.80	5861	5044.5	10939
T5	Control (No Zn)	86.48	5090	4303.0	9593
	SED	2.47	173.29	178.86	290.65
	$CD_{5\%}$	7.44	522.23	539.01	875.92
	CV (%)	4.64	5.30	6.36	4.78

TABLE 10

Effect of zinc compositions on yield components of rice

S. No	Treatment	Prod. Tillers/ m^2	Pan-icle Length (cm)	Pan-icle Wt (g)	Filled grains/ pan-icle	1000 grain wt (g)
T1	Zn HEDP @ 1 g/lt.	395	22.2	2.60	107	24.7
T2	Zn HEDP @ 2 g/lt	410	22.9	2.89	120	25.2
T3	Zn EDTA @ 1 g/lt.	396	22.3	2.60	105	24.6
T4	Zn EDTA @ 2 g/lt.	403	22.6	2.79	116	25.3
T5	Control (No Zn)	363	21.2	2.14	94	22.8
	S.Ed	8.90	0.31	0.08	3.22	0.69
	$CD_{5\%}$	26.81	0.95	0.25	9.69	2.09
	CV (%)	3.92	2.45	5.52	5.15	4.90

The above experiment showed that rice grain yield improved significantly with zinc (foliar) application at 20, 40 and 60 days after planting. Both the zinc compositions, Zn-HEDP and Zn-EDTA, improved the grain yield significantly compared to unsprayed control. Straw yield also responded similarly due to zinc compositions and doses. Plant height was significantly improved due to the higher dose of both Zn-HEDP and Zn-EDTA compositions compared to their lower dose and unsprayed check. Similarly, rice plant total biomass at both the doses of Zn-HEDP and higher dose of Zn-EDTA recorded significantly higher biomass compared to the lower dose of Zn-EDTA and the unsprayed check.

Productive tillers/m^2 panicle length and panicle weight were influenced in similar way as shown in Table 10. Zinc application irrespective of dose or composition improved productive tillers, panicle length and panicle weight significantly compared to unsprayed check. However, filled grain number per panicle and 1000-grain weight increased significantly with zinc application and with increasing dose with both the compositions.

The above results indicated that use of Zn-HEDP as foliar spray applied at 20, 40 and 60 DAT, improved rice yields significantly by positively influencing the yield parameters, viz. productive tillers/m^2, panicle length and weight, filled grains per panicle and 1000 grain weight.

The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in

all respects only as illustrative and not restrictive. The details of the invention, its object and advantages explained hereinbefore is to be understood that the invention, as fully described herein is not intended to be limited by the objects mentioned herein.

I claim:

1. A process for preparing a chelated fertilizer composition using compounds comprising disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP) and $ZnSO_4.H_2O$ (Zinc sulphate monohydrate), comprising the steps of:

dissolving Na_2 HEDP in water;

heating the dissolved mixture up to 100° C. in a non-stick temperature controlled vessel/reactor;

adding $ZnSO_4.H_2O$ and stirring to obtain mixture containing Zn-HEDP and P_2O_5;

maintaining the temperature at 100° C. and stirring the mixture until liquid portion evaporates; and

drying a composition thus obtained using drier to secure moisture free powder composition containing 17% Zn-HEDP and 21% P_2O_5.

2. A process for preparing a chelated fertilizer composition using compounds comprising disodium salt of Hydroxy Ethylidene Di Phosphonic Acid (Na_2 HEDP) and ZnO (Zinc Oxide), comprising the steps of:

dissolving Na_2 HEDP in water;

heating the dissolved mixture up to 100° C. in a non-stick temperature controlled vessel/reactor;

adding ZnO and stirring to obtain mixture containing Zn-HEDP and P_2O_5;

maintaining the temperature at 100° C. and stirring the mixture until liquid portion evaporates;

drying a composition thus obtained using drier to secure moisture free powder composition containing 23% Zn-HEDP and 29% P_2O_5;

adding 10% by weight dispersal powder; and

mixing in blender to obtain 21% Zn-HEDP and 26% P_2O_5.

* * * * *